CALIFORNIA ENERGY COMMISSION

Large HVAC Building Survey Information

Database of Buildings over 100,000 square feet (product 3.2.1)
(This item is located in the *Additional Documents* file)

Screening Interview Summary Report (product 3.2.2)

Onsite Inspection Summary Report (product 3.2.4)

TECHNICAL REPORT

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Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

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PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

This document is one of 33 technical attachments to the final report of a larger research effort called *Integrated Energy Systems: Productivity and Building Science Program* (Program) as part of the PIER Program funded by the California Energy Commission (Commission) and managed by the New Buildings Institute.

As the name suggests, it is not individual building components, equipment, or materials that optimize energy efficiency. Instead, energy efficiency is improved through the integrated design, construction, and operation of building systems. The *Integrated Energy Systems: Productivity and Building Science Program* research addressed six areas:

- Productivity and Interior Environments
- Integrated Design of Large Commercial HVAC Systems
- Integrated Design of Small Commercial HVAC Systems
- Integrated Design of Commercial Building Ceiling Systems
- Integrated Design of Residential Ducting & Air Flow Systems
- Outdoor Lighting Baseline Assessment

The Program's final report (Commission publication #P500-03-082) and its attachments are intended to provide a complete record of the objectives, methods, findings and accomplishments of the *Integrated Energy Systems: Productivity and Building Science Program*. The final report and attachments are highly applicable to architects, designers, contractors, building owners and operators, manufacturers, researchers, and the energy efficiency community.

This attachment, "Large HVAC Building Survey Information" (Attachment A-20), provides supplemental information to the program's final report within the **Integrated Design of Large Commercial HVAC Systems** research area. It includes three reports:

1. **Database of Buildings over 100,000 ft².** Microsoft Access database listing buildings over 100,000 ft² built in California since 1995, including their occupancy type.

2. **Summary of Site Screening Interviews.** Describes the results of telephone interviews used to identify large commercial buildings for site inspections and potential onsite measurements. The target buildings are located in California, have chilled water plants and VAV reheat system and have been built since 1995.

3. **Onsite Inspection Report for 21 Sites.** Summarizes results of the onsite building survey used to identify five sites for detailed monitoring of their HVAC equipment and operation. The survey covered 21 buildings ranging in size from 85,000 to 955,000 ft², with cooling capacities ranging from 230 to 2,300 tons. The onsite inspection reports describe each site's qualifications as a candidate for detailed monitoring.

The Buildings Program Area within the Public Interest Energy Research (PIER) Program produced these documents as part of a multi-project programmatic contract (#400-99-413). The Buildings Program includes new and existing buildings in both the residential and the non-residential sectors. The program seeks to decrease building energy use through research that will develop or improve energy efficient technologies, strategies, tools, and building performance evaluation methods.

For other reports produced within this contract or to obtain more information on the PIER Program, please visit www.energy.ca.gov/pier/buildings or contact the Commission's Publications Unit at 916-654-5200. All reports, guidelines and attachments are also publicly available at www.newbuildings.org/pier.

ABSTRACT

This set of three reports was produced as a part of the Integrated Design of Large Commercial HVAC Systems research project, one of six research elements of the *Integrated Energy Systems: Productivity and Building Science* Program. This program was funded by the California Energy Commission's Public Interest Energy Research (PIER) Program.

This project focused on problems of integrated HVAC system design in large buildings. As part of their work to develop building-science solutions to these problems, the research team monitored the performance of large commercial HVAC systems in five California buildings. This document contains three reports describing early research tasks designed to identify buildings suitable for monitoring.

1. **Database of Buildings over 100,000 square feet.** A list of California commercial buildings over 100,000 ft² that entered the construction phase in the five-year period starting in 1995, derived from FW Dodge data.

2. **Screening Interview Summary Report.** A summary of the telephone interviews used to identify large commercial buildings for site inspections. From the projects in the above database, a random sample of 478 sites was selected; telephone surveys resulted in 33 qualified buildings, 22 of which were recruited for site inspections.

3. **Onsite Inspection Summary Report.** A summary of the onsite building surveys used to identify five sites for detailed monitoring. The survey covered 22 buildings on 20 sites, ranging in size from 85,000 to 955,000 ft², with cooling capacities ranging from 230 to 2,300 tons. The survey results were used to select the final five sites.

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Screening Interview Summary Report

Integrated Design of Large Commercial HVAC Systems

Deliverable: 3.2.2

August 10, 2001

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Executive Summary

This report describes the results of telephone interviews used to identify large commercial buildings for site inspections and potential on-site measurements. The target buildings are located in California, have chilled water plants and VAV reheat system and have been built since 1995. A potential population of roughly 1,300 sites was identified from FW Dodge construction activity data. Interviews with 478 sites resulted in 33 qualified buildings, 22 of which were successfully recruited for subsequent site inspections. Original targets were 30 inspections resulting from up to 300 interviews.

Introduction

This report describes results of one of the early tasks in the PIER element "Integrated Design of Large Commercial HVAC Systems". This project is one of six research projects managed by the New Buildings Institute and sponsored by the California Energy Commission.

This research element aims to answer many long-standing questions posed by designers and operators of large variable-air-volume (VAV) systems and chilled water plants. These are among the most common types of heating, ventilation and air conditioning (HVAC) systems for large buildings in California.

These central systems can be much more efficient than collections of packaged equipment, but it has long been recognized that they operate very inefficiently. Designers face a systems integration problem: even with the most efficient components, if the components are not well matched, or if they are not controlled properly, then the overall system can be very inefficient.

During Program Years 1, 2 and 3, we will conduct field studies of HVAC systems in large commercial buildings to quantify problems with component/system selection as well as building controls and operation that cause energy inefficiencies. This detailed information will feed our research on new integrated design solutions and will be used to determine savings potentials. The design guidelines resulting from this study, which will be produced in Year 3, could have a dramatic impact on HVAC system design in California. We will also document the statewide savings potentials and consider future code upgrades.

This report summarizes results of program task 3.2.2, telephone interviews used to identify sites for on-site inspection and potential on-site measurements.

Methodology

Study Site Selection Problem

It is expensive to monitor, conduct experiments and analyze detailed performance data for large buildings, especially when our purpose is to thoroughly understand the HVAC system and how its design might be improved. Accordingly, the budget allows for only a small group of study sites, probably five. We need to carefully select these sites to represent the VAV applications that will be most common in the next five to ten years. Our best guide to the future is looking at the recent past. This would be an easy task, if we had a complete list and description of all VAV installations that went on-line in California during the last five years. No such list exists, so we need to devise a cost-effective method for creating a representative list. Once we have a list we can gather more detailed information, via telephone survey and site inspections of a random sample, and ultimately, make a very careful choice of five representative study sites. Or course these sites must be both representative and willing to put up with our team crawling all over the building and its systems for extended periods of time.

Building an Initial List of Projects

For many years, there has been only one source of data that comes close to providing a list of construction activity for large areas like the State of California. This source, FW Dodge (a McGraw Hill

Company), attempts to track construction projects from the early planning stages through start of construction and sells data on these projects to the design and construction industry that is primarily used for marketing and sales purposes. The Dodge data is not perfect, but it is the only cost-effective choice. We purchased from Dodge a list of all non-residential building projects (new, additions and alterations) that entered the construction phase in the five-year period starting in 1995. In total, there are 54,154 projects listed in this database.

The Dodge data provides limited information about each of the projects, but unfortunately, no direct indication of whether VAV HVAC systems were installed as part of the project. However, there is enough information to allow us to shorten the list of possible VAV application sites. In particular the database contains a project type code that indicates the primary purpose of the project, e.g., government office, schools, and hospitals. The database also contains information about the project floor area, construction value, and type of construction (new, additions and alterations).

We have applied the following criteria to narrow the list of projects to those that are likely to be good candidates for this study.

1. **SF > 100,000**. Most VAV applications occur in projects where more than 100,000 SF of floor area needs to be conditioned. We have eliminated all projects smaller than 100,000 SF.
2. **Applicable Project Types**. VAV is a good choice when conditioning loads are variable due to variability in internal gains or ventilation. They are not common for a number of project types such as food service or hotels. These types of projects have been eliminated from the list.
3. **No Additions**. Additions to existing facilities often add to the complexity of the HVAC configuration. Chillers may be shared between old and new portions of the facilities and controls introduced that are not fully integrated with pre-existing control systems. These conditions could pose major challenges to the research activity at a study site and therefore we have eliminated additions from the list.
4. **Only Major Renovations**. Many of alteration projects found in the Dodge database have low construction value per square foot, i.e., less than $100/SF. We want study sites that have completely new HVAC systems. We are most likely to find these through projects that have construction costs comparable to new construction costs, or higher. Alteration projects were eliminated if the construction costs were less than $100/SF.

Table 1 was created from the list of projects that remain in the database after projects were eliminated based on these criteria. The table shows how projects are distributed between market segments and between new construction and high-value alterations (alteration projects that have construction value per SF > $100/SF).

Table 1. New Construction and High Value Alteration Projects in FW Dodge Database (1995-99) Which May Have New VAV HVAC systems

Use Type	New Construction Project	High Value Alteration Projects	All Projects
Offices (private and governmental)			
No. of Projects	827	14	841
Floor Area (1000 SF)	204,123	3,377	207,500
Construction Value / SF	56	147	203
SF / Project	246,824	241,179	488,002
Health			
No. of Projects	87	5	92
Floor Area (1000 SF)	20,949	895	21,844
Construction Value / SF	114	203	316
SF / Project	240,789	179,028	419,817
Education			
No. of Projects	66	13	79
Floor Area (1000 SF)	14,590	2,175	16,765
Construction Value / SF	104	150	254
SF / Project	221,054	167,337	388,391
Miscellaneous			
No. of Projects	290	26	316
Floor Area (1000 SF)	63,521	6,707	70,228
Construction Value / SF	75	166	241
SF / Project	219,039	257,944	476,984
All Types			
No. of Projects	1,270	58	1,328
Floor Area (1000 SF)	303,183	13,154	316,336
Construction Value / SF	66,361	161,104	70,301
SF / Project	239	227	238

Selecting a Sample for Telephone Surveys

The performance of VAV systems is influenced by a number of factors. The type of use (office versus education) will be important. In addition, climate will be a major factor. Ultimately, we are limited to a very small group of monitored study sites, so we can target only a small number of important combinations of these factors. Table 2 shows our recommended approach. We have placed each of the 1,328 possible projects (from Table 1) into one of two climate zones. The "Hot" zone includes the central valley and much of the far southern portion of the California (specifically CEC climate zones 7-15). The "Mild" zone encompasses mostly the central and northern coastal areas of the state (CEC climate zones 1-6 and 16). In addition, we have collapsed the projects into two use type categories (office and everything else). Table 2 shows the number of projects in the four cells created by this use type by climate zone matrix. We propose to gather data via telephone interviews with the managers of these facilities for a total of 300 projects selected at random from the list. Further, as shown in the table, we propose to allocate the sample so that we complete 75 interviews for projects in each of the four cells of this table.

Table 2. Sample Targets by Use Type and Climate Zone

	Climate Zone								
	Hot			Mild			All		
Use Type	In List	Sample		In List	Sample		In List	Sample	
		No.	%		No.	%		No.	%
Office	581	75	13%	260	75	29%	841	150	18%
Other	319	75	24%	168	75	45%	487	150	31%
All	900	150	17%	428	150	35%	1328	300	23%

Conducting Telephone Surveys with Facility Managers

Members of our engineering staff completed telephone interviews with the facility managers and other members of the facility staff for the sample of Dodge projects described above. The survey form used during these interviews is listed in Appendix A. The first section of the interview listed under ***Initial Contact and Screening*** allows us to make an early screening decision. This keeps the survey as brief as possible for projects that would not be good candidates for this study. For the projects that pass all of these criteria, we continue to collect the other data enumerated in the table, so that we can use it in selecting the best candidates for an on-site inspection.

Results

Telephone interviews for 478 sites yielded 33 qualified buildings, of which 22 were successfully recruited for on-site inspections (includes 20 sites; one site had three buildings). The number of interviews required turned out to be greater than planned. The original plan anticipated needing up to 300 interviews to identify 30 sites for inspection, a 1-in-10 rate. The actual success rate was about 1-in-22. The cost of continuing interviews in order to find 30 sites was considered to be prohibitive; therefore, the target for number of inspections was reduced. The reduction is considered acceptable because the primary purpose of the inspections is to identify five monitoring candidates.

The unanticipated difficulty in identifying sights raised a few questions. First of all, we questioned whether our population data from FW Dodge adequately covered the total population. To investigate, we conducted a short survey of utility staff, manufacturers and designers to check for examples that had not appeared on our list. These contacts are listed in Appendix B. Together they identified ten buildings. Four of the ten buildings identified were also included in the FW Dodge database. Of the remaining six buildings, five did not meet our criteria, but one building was found to be qualified. Based on this check, we found that the FW Dodge database was not perfect, but felt comfortable that we had not missed a significant number of potential candidates.

A second question raised by the difficulty in identifying sites is whether we are addressing only a small part of the market with our design guideline topics. We were aware that a majority of new commercial buildings use packaged DX cooling systems, but believed from experience that a large fraction of total cooling capacity is served by chilled water plants and VAV reheat systems, which are typically installed in larger buildings. Our telephone survey results do not provide an accurate answer to this question, as discussed in more detail below, but they do show that 18% of all surveyed sites have some form of chilled water system. In addition, an unknown number of the packaged DX systems will serve VAV reheat air distribution systems, and many of the guideline topics will apply to them as well.

The following sections describe some of the characteristics of the qualified sites as well as the disqualified sites.

Qualified Sites

The following graphs display characteristics for the 33 buildings that meet our selection criteria. The same level of information is not available for disqualified sites because the telephone interview was terminated if a site did not meet screening criteria.

Figure 1 Building Types for the Qualified Sites

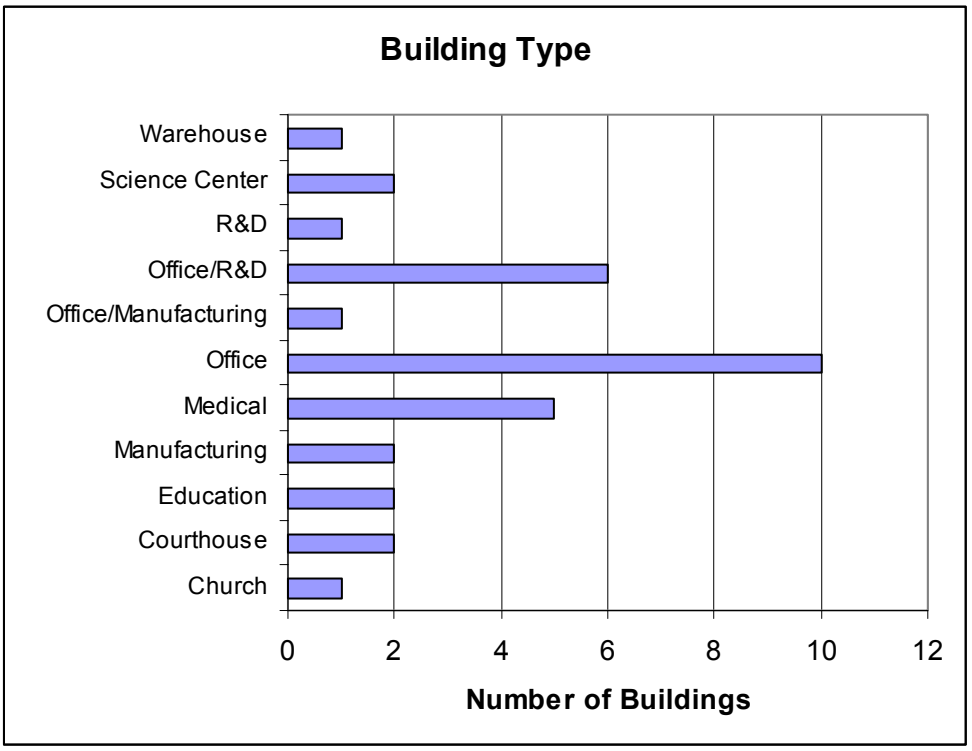


Figure 2 Floor Area of Qualified Buildings

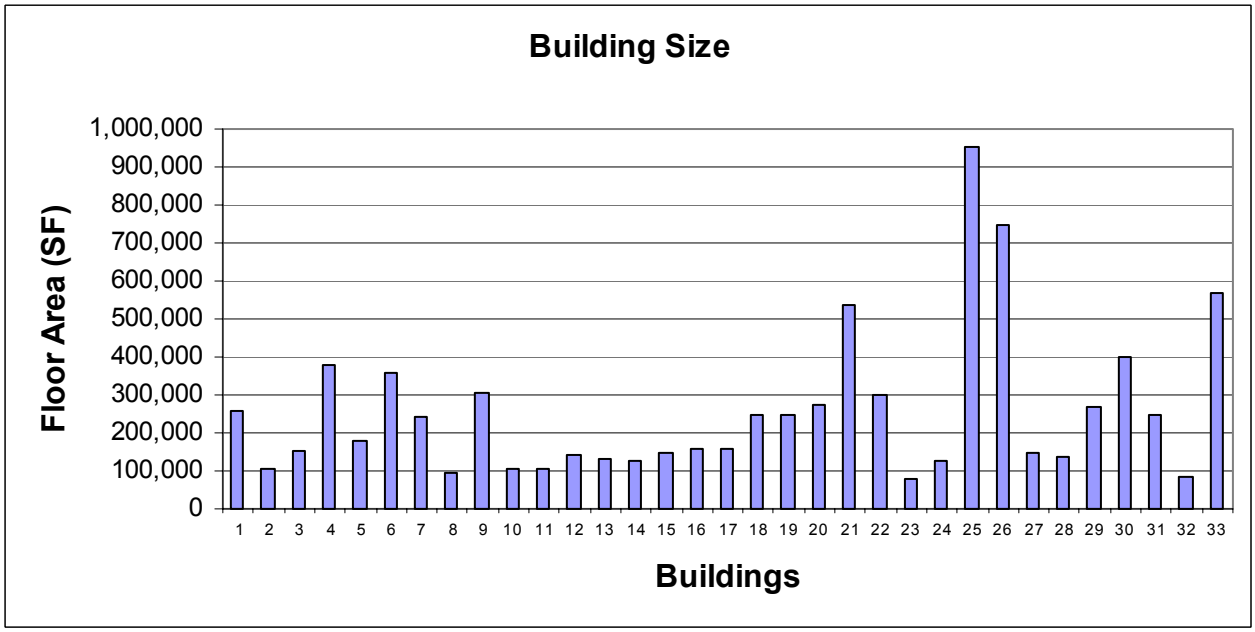


Figure 3 Air Handler Quantity in Each of the Qualified Buildings

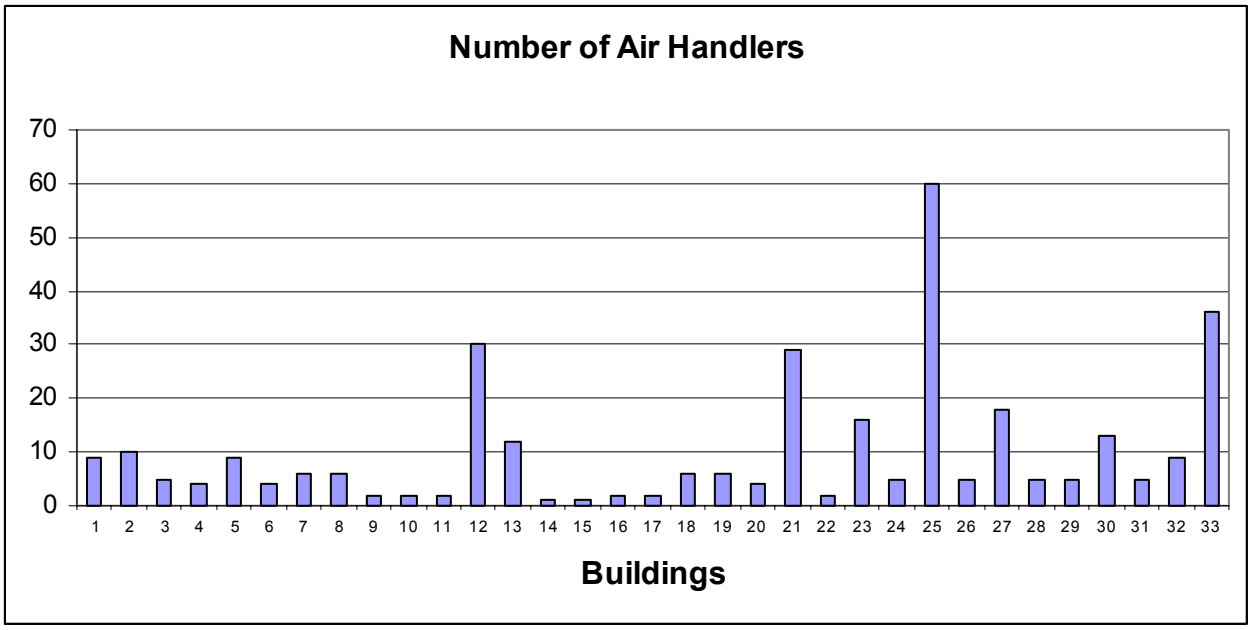
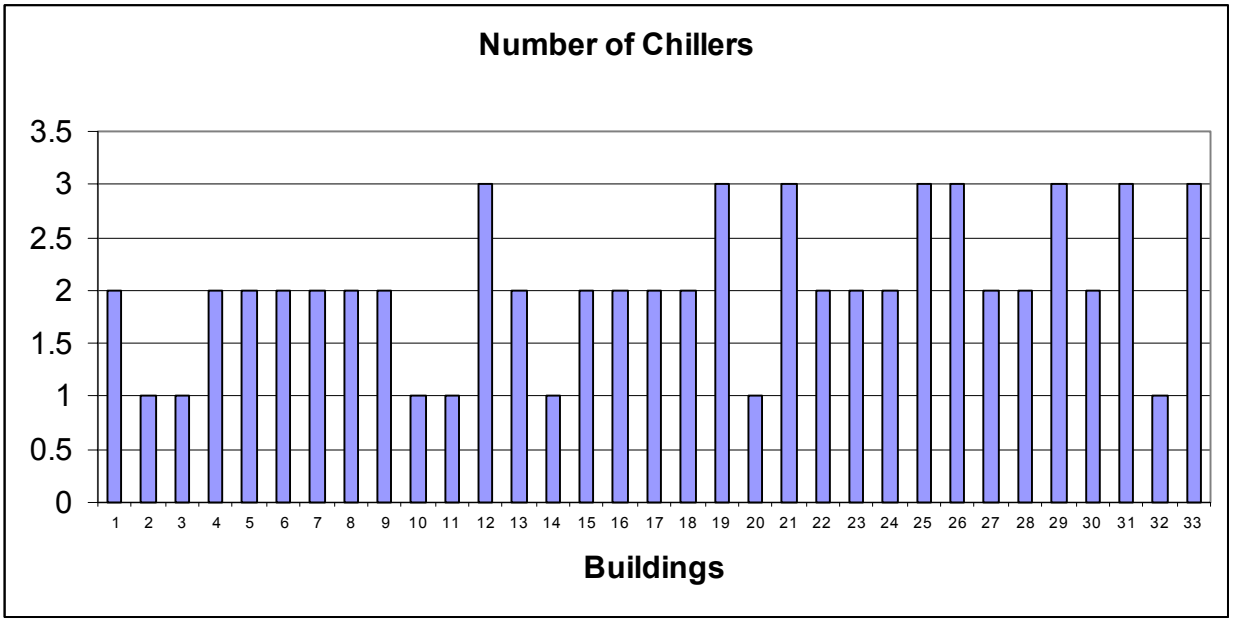


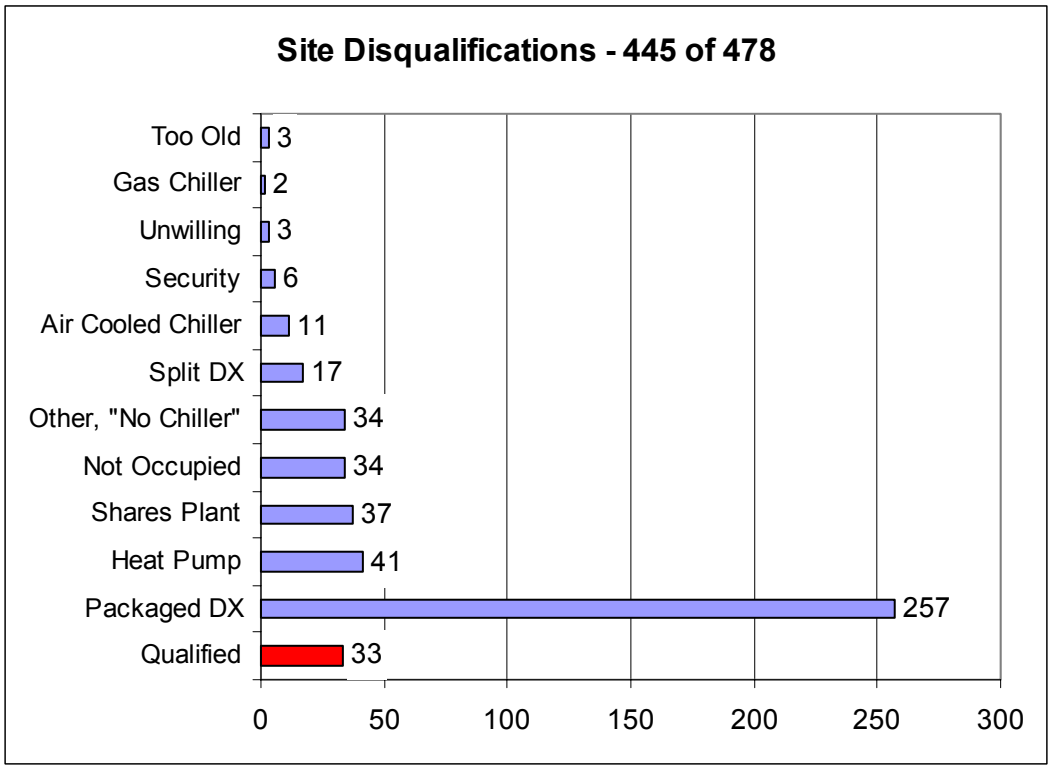
Figure 4 Chiller Quantity in Each of the Qualified Buildings



D i s q u a l i f i e d S i t e s

The following graph shows reasons for disqualification. (Qualifying sites have water-cooled chillers and VAV air handlers with terminal reheat). Unfortunately, the interview data cannot be used to estimate the fraction of total floor area or cooling capacity served by qualifying systems because the primary purpose of the interview was to identify qualifying sites. Therefore, interviews were terminated when it was determined that the system type did not match criteria for the study. What the interview results can show is that the majority of these buildings have packaged direct expansion cooling systems (54%). Roughly 18% have some sort of chilled water system and 8% of the total sample meets all selection criteria.

Figure 5 Summary of Reasons for Site Disqualifications



Appendix A Telephone Survey Form

Integrated Design of Large Commercial HVAC Systems Telephone Screening Interview

Interviewer Initials:
Date: / /
DR_NUM:

Initial Contact and Screening

1. Contact the sites using the phone numbers shown on the sample control listing, or obtain the number via a reverse directory based on the site address. The objective is to find someone associated with the site that is familiar with the facility's HVAC system. You may have to talk with a number of people before your find the correct person. You can try asking for the facility manager, facility engineer, building engineer, or building operator. As necessary, explain that you are with SBW Consulting, Inc. Our firm is under contract to the California Energy Commission to conduct research on the performance of HVAC systems for large commercial buildings. This study will provide better guidelines for the design, construction and operation of these systems.

Contact Name:	Notes:
Title:	
Phone Number:	

2. Determine whether the facility exists (the Dodge database information may be incorrect) and confirm that it has a California address. If it does not exist or is not in California, thank the contact for their time and end the interview.

Facility Exists?	**Yes**		Street Address:
	No		City:

3. During the interview the initial contact may indicate that we need to speak with other staff about certain questions. Record contact information for these staff. Contact them as needed to obtain answers to these questions.

	Contact #2 Name:	Contact #3 Name:
	Title:	Title:
	Phone:	Phone:

4. Explain that we need information about the facility's HVAC system. The survey should take a few minutes to complete. Confirm that the contact knows about these systems and is willing to complete the interview.	Is the facility manager or his/her staff willing to answer these questions? (Must be yes).	**Yes**	
		No	
5. Has this project been completed?		**Yes**	
		No	

6. Was this a "new building" construction or "renovation"?	New Construction (if renovation go to question 8)	
	Renovation (if new construction go to question 7)	
7. If the project is a renovation, did the renovation work include new chillers and VAV equipment? (Must be Yes)	**Yes**	
	No	
8. If the project is a new building, does it encompass at least one building, including chillers, cooling tower, VAV equipment and controls? (Must be Yes)	**Yes**	
	No	
9. Is the project fully occupied? If the initial response is no, ask if there are multiple tenants occupying the project. If yes, consider the project fully occupied if more than 75% of the space is occupied. (Must be Yes)	**Yes**	
	No	
10. As part of this project, how much conditioned floor space was built or substantially renovated since 1995? (Must be >100,000 SF)	Conditioned SF	
11. What % of the space built or renovated by this project is conditioned by VAV systems? (Must be >50%)	VAV %	
12. What type of cooling system does this project have? (Must be a chilled water system)	Chilled water system	
	Direct Expansion	
13. Are the chillers gas-fired? (Must be No) (if gas fired, the primary chiller must be electric)	Yes	
	No	
14. Are the chillers water-cooled? (Must be Yes)	**Yes**	
	No	
15. Does chilled water provide most of the cooling for this project? (Must be yes)	**Yes**	
	No	
16. Does the central plant of another building provide chilled water to this project? (Must be No)	Yes	
	No	
17. Does the central plant of this project provide chilled water to another building? (Must be No)	Yes	
	No	
18. Do the VAV systems serve high-security areas where it would be difficult to arrange access for inspection and monitoring of equipment? (Must be No)	Yes	
	No	
If the project fails any of the screening questions, thank the contact and terminate the interview. If not, obtain answers to the remaining questions.		

Facility Characteristics			
19. What is the primary use of the buildings [built] [renovated] as part of this project, e.g., hospital, office, school, government administration, etc.?			
20. How many buildings comprise this project?			
21. Describe any major changes, expected to start within three years, which will significantly change the buildings/HVAC systems comprising this project.			
VAV			
22. Number of Air Handling Units at this Project			
23. How many of the AHUs are VAV systems.			
24. What is the predominant VAV system type?	Single Duct		
	Dual Duct		
25. If single duct, is there terminal reheat or a separate heating system?	Terminal reheat		
	Separate heating system		
26. Do the Air Handler Units have adjustable speed drives?	Yes		
	No		
27. Are there other constant volume cooling systems that cool all or a large portion of the space served by the VAV systems?	Yes		
	No		
Chiller			
28. Number of chillers.			
29. Capacity of each (tons).			
30. Are there variable speed drives on the compressor motors of these chillers?	Yes		
	No		
31. Are there any process loads or constant volume system that are served by this chiller plant?	Yes		
	No		
32. If yes, is this constant volume load greater than 30% of the chiller capacity?	Yes		
	No		

Controls			
33. What is the make/model of the DDC system at this project? (If more than one DDC ask about the primary system.)	Make		
	Model		
34. Are the VAV systems controlled by a central DDC system?		Yes	
		No	
35. Are chillers and cooling towers controlled by this DDC system?		Yes	
		No	
36. Are the VAV terminal units controlled by this DDC system?		Yes	
		No	
37. Can this DDC system record trend logs?		Yes	
		No	
38. If there is a separate heating system for the space served by the VAV systems, is this heating system controlled by this DDC system?		Yes	
		No	
39. Are there flow and temperature sensors for chilled water?	Temperature	Yes	
	Flow	No	
40. Are there flow and temperature sensors for condenser water?	Temperature	Yes	
		No	
	Flow	Yes	
		No	

Interest and Follow-up			
41. Explain to the contact that has the greatest authority over the facility that we are conducting this interview with 300 facility managers throughout California. We will use this information to select 30 buildings that are most representatives of recent VAV applications. We will need to inspect these facilities to gather more detailed information about the HVAC system and other energy related features before we select 5 that will receive special metering equipment and a free analysis of possible energy efficiency improvements.	Is the contact interested in participating in this study?	Yes	
		No	
42. If yes, get contact information (if it is a different person) for the person who has final authority to authorize site inspection.			
Name:	Notes:		
Title:			
Phone Number:			
43. Does person with final authority approve of the site inspection?		Yes	
		No	
44. Obtain contact information for the person who can schedule the site inspection.			
Name:	Notes:		
Title:			
Phone Number:			

Appendix B - Identification of Potential Qualified Sites from Sources other than the Dodge Database

SBW contacted an individual at several different businesses seeking to obtain information regarding buildings that might qualify to participate in the HVAC system study. The purpose for this task was to test whether the Dodge Database is a relatively complete list of the building projects. If the individuals provided information regarding buildings that met the selection criteria used in developing the Dodge Database but those buildings were not in the Database, that would indicate the Database is not comprehensive. In addition, the buildings identified by the individuals might provide the project team with additional qualified buildings to recruit for the study. Conversely, if the buildings identified by the individuals are buildings which are included in the Database, that would suggest the database is relatively complete.

The following is a list of the individuals that were contacted and asked to provide information regarding buildings that might qualify for inclusion in the study:

- Wayne Womer, PG&E
- David Kuo, SCE
- Clark Bizel, Flack & Kurtz, Inc.
- Sarah Nicholson, ARUP
- Jeff Cox, Johnson Controls
- John Clark, Trane - LA
- Dan Hall, Trane – SF
- Richard Swank, Trane – Sacramento
- Mazin Kellow – SMUD

Several of the individuals listed above provided information about one or more buildings. Together they identified 10 buildings. Four of the ten buildings identified were included in the Dodge Database. Five buildings were not qualified to participate in the study, however, one building was found to be qualified to participate.

Onsite Inspection Summary Report

Integrated Design of Large Commercial HVAC Systems

Deliverable: 3.2.4

August 10, 2001

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Executive Summary

The report summarizes results of the on-site building survey that was used to identify five sites for detailed monitoring. The survey covered 22 buildings on 20 sites. The buildings range in size from 85,000 to 955,000 square feet, and cooling capacities range from 230 to 2,300 tons. Survey data were compiled in 10-page forms describing the space types, air handlers, chilled water plants and control systems. Selected building plans and control system trend logs were also collected.

The survey data were used to make a preliminary selection of five sites, including three offices, one college building and one courthouse.

Introduction

This report describes results of one of the early site survey tasks in the PIER element "Integrated Design of Large Commercial HVAC Systems". This project is one of six research projects managed by the New Buildings Institute and sponsored by the California Energy Commission.

This research element aims to answer many long-standing questions posed by designers and operators of large variable-air-volume (VAV) systems and chilled water plants. These are among the most common types of heating, ventilation and air conditioning (HVAC) systems for large buildings in California.

These central systems can be much more efficient than collections of packaged equipment, but it has long been recognized that they operate very inefficiently. Designers face a systems integration problem: even with the most efficient components, if the components are not well matched, or if they are not controlled properly, then the overall system can be very inefficient.

During Program Years 1, 2 and 3, we will conduct field studies of HVAC systems in large commercial buildings to quantify problems with component/system selection as well as building controls and operation that cause energy inefficiencies. This detailed information will feed our research on new integrated design solutions and will be used to determine savings potentials. The design guidelines resulting from this study, which will be produced in Year 3, could have a dramatic impact on HVAC system design in California. We will also document the statewide savings potentials and consider future code upgrades.

The site inspections described in this report comprise Task 3.2.4. Their purpose is to provide information for selection of five sites for detailed monitoring.

Methodology

The telephone interviews to identify these sites are described in a separate report, *Screening Interview Summary Report - Integrated Design of Large Commercial HVAC Systems*. As a result of the interviews, facility managers for 22 buildings on 20 sites agreed to allow site surveys.

The survey process included several steps. Appendix A includes text of a letter used to confirm participation. Appendix B includes the surveyors pre-visit checklist form. Appendix C is the text of a confirmation fax reminding the facility manager of the survey date and providing instructions for reproduction of plans.

Information collected during the visits is contained in 10-page survey forms that were completed for each building. An example from one of the sites is included as Appendix D. In addition to the form, selected sheets from building plans and sample trend log reports from the control system were collected. A typical visit required four to six hours on-site.

Results

Table 1 shows characteristics of the 22 surveyed buildings sorted from largest to smallest, and the subsequent figures provide illustrations of the same information.

The surveys show that chilled water plants are conservatively sized, ranging in cooling capacity as high as 100 s.f./ton to nearly 500 s.f./ton. Most fall in the range of 200 to 400 s.f./ton.

Table 1 Summary of Building Characteristics for 22 Surveyed Buildings

	Floor Area (SF)	Cooling Capacity (tons)	Cooling Capacity (sf/ton)	Building Type	Location	Qty. Air Handlers	Qty. Chillers	CHW Pumping System Type
1	955,000	2,300	415	office	Sacramento	58	3	Primary/secondary
2	750,000	1,550	484	office	Oakland	5	2	Primary/secondary
3	570,000	1,650	345	courthouse	Sacramento	32	3	Primary/secondary
4	500,000	1,350	370	office	Los Angeles	29	3	Primary only
5	400,000	1,000	400	medical	Salinas	13	2	Primary-only, var flow
6	307,000	800	384	office	Santa Clara	2	2	Primary/secondary
7	305,000	1,200	254	office	San Jose	2	2	Primary/secondary
8	296,000	1,300	228	office	Foster City	2	2	Primary/secondary
9	272,000	860	316	office	Emeryville	5	4	Primary/secondary
10	270,000	2,325	116	medical	Sacramento	5	3	Primary/secondary
11	250,000	800	313	office/mfg	El Torro	22	2	Primary only
12	250,000	600	417	courthouse	San Francisco	5	3	Primary only
13	200,000	800	250	medical	San Diego	9	2	Primary/secondary
14	180,000	880	205	church	Palm Desert	9	2	Primary only
15	164,000	500	328	office	San Jose	2	2	Primary only
16	145,000	400	363	education	Orange	5	2	Primary only
17	135,000	436	310	science center	San Jose	5	2	Primary/secondary
18	120,000	300	400	office	San Jose	1	1	Primary/secondary
19	105,000	500	210	office	San Jose	1	2	Primary/secondary
20	105,000	500	210	office	San Jose	1	2	Primary/secondary
21	94,000	260	362	medical	Los Angeles	6	2	Primary only
22	85,000	230	370	science center	Oakland	9	1	Primary/secondary
Total	6,458,000	20,541						

Figure 1 Breakdown of Survey Sites by Building Type

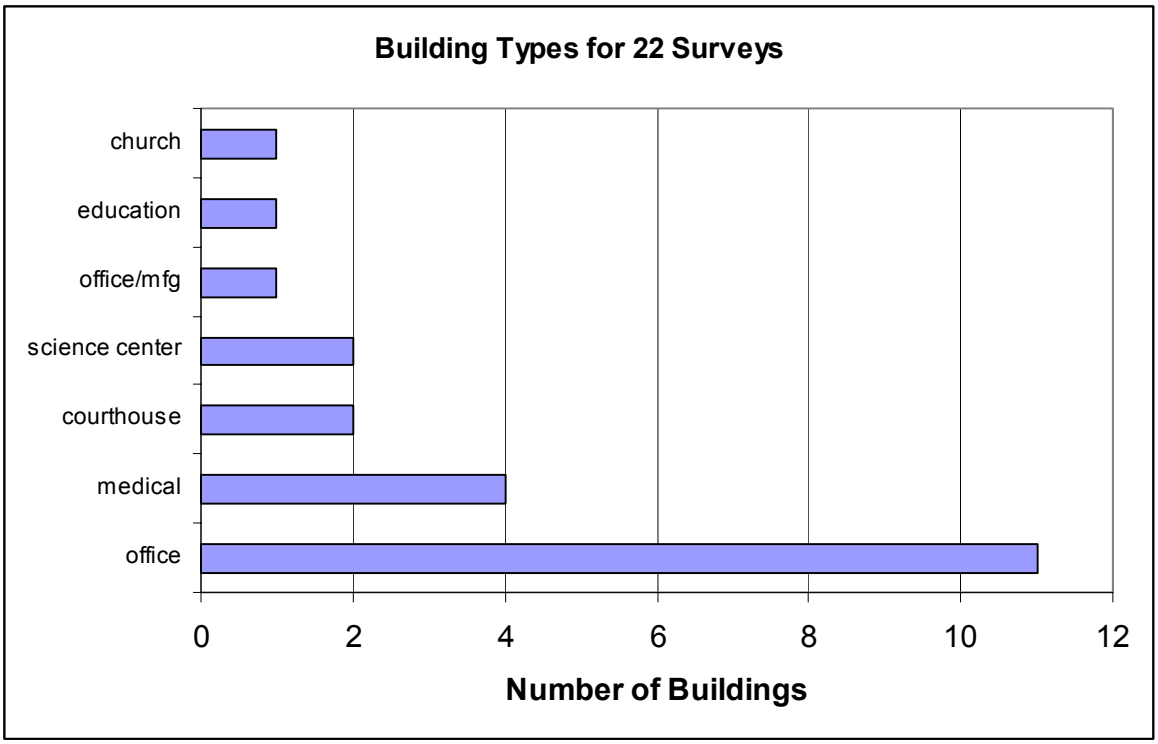


Figure 2 Floor Area of Surveyed Buildings

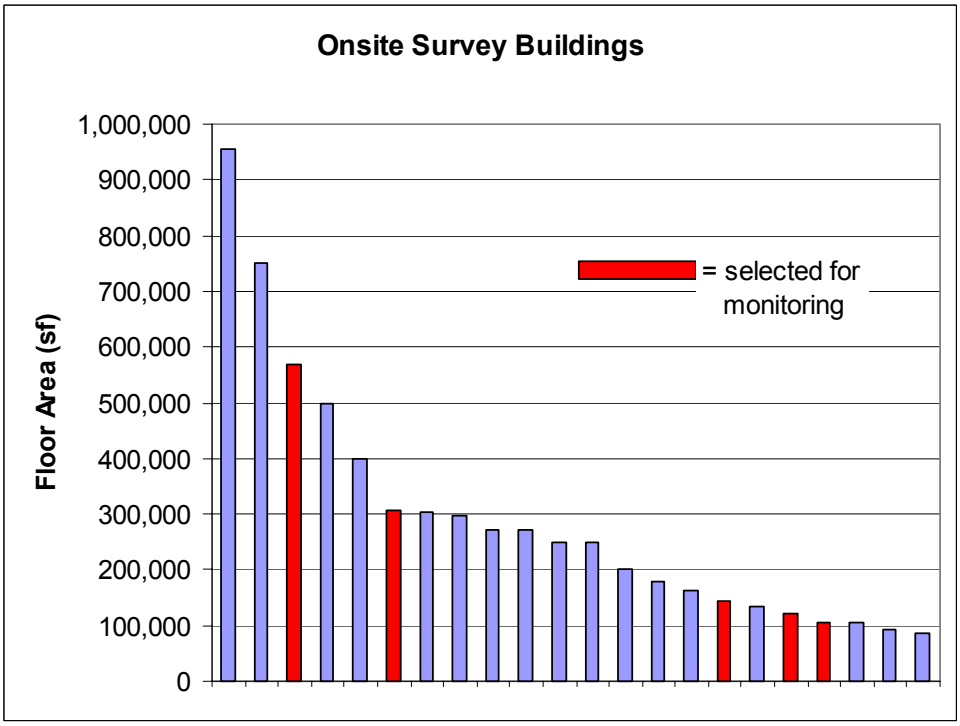


Figure 3 Chiller Capacity at Surveyed Buildings

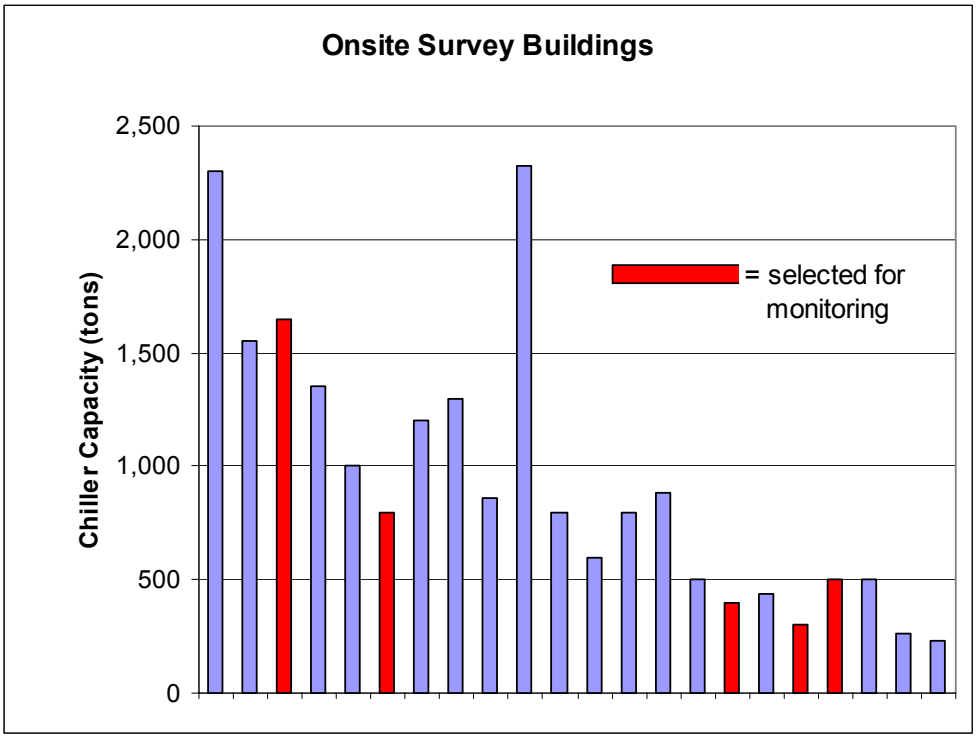
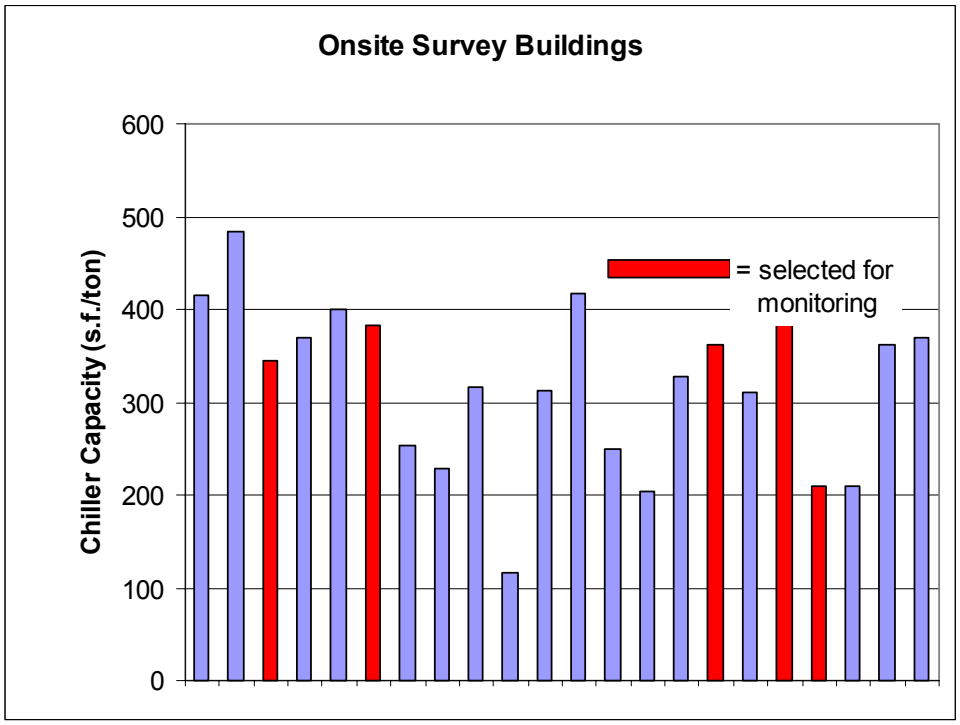


Figure 4 Relative Chiller Capacity for Surveyed Buildings



The site survey information can be used for a rough estimation of new construction population size and HVAC energy and demand. The 22 buildings total 6.5 million square feet of floor area and 20,500 tons of cooling capacity. Each of these buildings was completed during a roughly 2.5 year period. Therefore, annual average construction volume for this sample is 2.6 million square feet per year and 8,200 tons per year. We do not know exactly how the size of our sample compares to the total population that would be affected by the guidelines, but a conservative estimate is that the sample equals about 50% of the annual construction. Therefore, the new construction population size is about 5.2 million square feet per year and 16,400 tons per year. Typical peak demand for HVAC in these buildings is about 1.0 kW/ton, and energy consumption is equal to roughly 1000 kWh/ton/year. Therefore, annual new construction for the relevant population accounts for about 16.4 MW of peak electric demand and 16,400 MWh/yr of electricity consumption (for HVAC).

Preliminary Monitoring Site Selections

The five preliminary selections for detailed monitoring are indicated on the graphs above.[1] These sites were chosen to provide a reasonable amount of diversity of system characteristics while also providing the best opportunities for successful data collection. Therefore, an important criterion is the presence of a control system with data trending capabilities and sensors measuring as many of the desired points as possible.

Site #1

- Office
- San Jose
- 307,000 sf
- 2 AHUs

[1] Site selection is subject to change depending on findings of followup visits and measurement planning.

- Two 400 ton chillers
- Occupancy Dec. 2000

Site #2

- Office
- San Jose
- 105,000 sf
- 1 AHU
- Two 250 ton chillers
- Incl. Data center
- Occupancy Oct. 1999

Site #3

- College
- Orange, CA
- 145,000 sf
- 5 AHUs
- Two 200 ton screw chillers
- Classroom, courtroom, office, library
- Occupancy Apr. 1999

Site #4

- Courthouse
- Sacramento
- 570,000 sf
- 30+ AHUs
- Two 650 ton, one 350 ton chillers
- Extensive EMCS
- Occupancy Jan. 1999

Site #5

- Office
- San Jose
- 120,000 sf
- 1 AHU
- One 300 ton chiller
- Separate perimeter heating system
- Occupancy Oct. 1999

Appendix A Text of Survey Confirmation Letter

Dear :

My firm represents the New Building Institute (NBI), which is operating under contract to the California Energy Commission (CEC). The CEC has asked NBI to conduct a program to improve the design and energy efficiency of large facilities that use Variable Air Volume (VAV) air conditioning systems. We have contacted owners and operators of more than 500 large facilities in California and have identified 25 that are best suited for this program.

Over the next two months, we will complete on-site inspections of these 25 facilities so that we can select five for the final phase of this program. At these facilities we will install a performance monitoring system. The system will collect data during the summer and fall of 2001. Our team will analyze this data to identify ways to reduce energy costs. If any are found we will work with the facility management to help make these improvements. The monitoring system will continue to operate through the summer and fall of 2002 to document the effects of these improvements. The results from all five facilities will be used in developing guidelines for design, construction and operations that can be used by facility owners and managers throughout California.

We plan to send one of our senior engineers and an assistant to spend one day in your facility to collect the required information. They will need to meet for about an hour with a person who is familiar with your HVAC equipment and its operation. They will also need about an hour with your control system operator/programmer. In addition, our staff will need access to the chilled water plant and major equipment rooms.

It will greatly simplify the data collection process if we can get some information from your staff before the on-site inspection. Much of this information can be obtained from your facility plans and operator's documentation. Of course, we will arrange for and pay a courier/photo copy service to make a copy of these documents if your staff can tag the appropriate pages. The pages we need are:

- Control Diagram showing typical VAV box controls
- Mechanical Equipment Schedule
- Piping Schematic for Chilled Water Plant
- Electrical Riser Diagram
- System Communications Riser Diagram
- Intended Sequence of Operations for Air Handlers and Chillers
- From your operator's documentation we need the Manufacturer’s Test Report for each chiller.

Two other items will also be very useful.

- Recent electrical and gas bills
- Brief trend logs for readings from flow and supply/return temperature sensors on the chilled water and condenser water loop (which if available, can be printed out by your control system)

Your assistance with this program is greatly appreciated. If you have any questions or concerns do not hesitate to contact me by phone or e-mail.

Appendix B Scheduling and Pre-Visit Preparation Form

Integrated Design of Large Commercial HVAC Systems Initial Site Survey

Scheduler Initials:
Date: / /
Site ID:

Scheduling and Pre-Visit Preparations

1. Call the person shown on the telephone-screening interview as the contact for scheduling the site survey. Tell them we are ready to start the next phase of this program — conducting on-site inspection at 25 facilities that have chilled water VAV systems. We would like to fax or e-mail a brief letter (end of this section) which describes this program and the assistance that we need in completing the on-site inspection. Confirm and record their contact information and send the letter via e-mail or fax (as they request).

Primary Contact	
Name:	E-mail:
Title:	Fax:

2. We plan to send one of our senior engineers and an assistant to spend one day in your facility to collect the required information. They will need to meet for about an hour with a person who is familiar with your HVAC equipment and its operation. They will also need about an hour with your control system operator/programmer. In addition, they will need access to the chilled water plant and major equipment rooms. Ask for contact information for the HVAC and controls contacts.

HVAC Contact	Controls Contact
Name:	Name:
Phone Number:	Phone Number:
Pager/Mobile:	Pager/Mobile:
E-mail:	E-mail:

3. If HVAC and Controls contacts are different people ask what the best way is to schedule a day that will work for both of them.

4. We can accomplish our work more quickly and take up less of your valuable staff time, if we can arrange to get copies of selected pages from your electrical and mechanical as-built drawings and operator's documentation. (See list in letter). If you can tag the appropriate pages, we will pay for a courier and photocopy service to make a copy. It would be best if we can get our copy before we arrive at your facility. Do you have a preferred service (record name and phone #)? If not we will make the necessary arrangements.

Preferred photo copy service		
Name:	City:	Phone:

Notes on what Wendy and field staff need to do to complete this process:

5. We also need electric and gas billing data for your facility. Ask what the best way is to get copies of bills for recent months (up to a full year if readily available). If necessary, get contact information for another person in the organization that can make copies of these bills. Have them mailed, faxed or picked up by field staff.

Contact for Copy of Bills	
Name:	E-mail:
Title:	Phone

Scheduling and Pre-Visit Preparations

Notes on what field staff need to do to complete this process:

6. Explain that once we complete surveys of 25 sites, we will select 5 facilities for the final phase of this program. At these facilities we will install a performance monitoring system. The system will collect data during the summer and fall of 2001. Our team will analyze this data to identify ways to reduce energy costs. If any are found we will work with the facility management to help make these improvements. The monitoring system will continue to operate through the summer and fall of 2002 to document the effects of these improvements. If your facility were selected, would you be interested in being one of these monitored sites? Who should we contact in your organization that would be able to authorize your participation in this program	Yes	
	No	

Name:	E-mail:
Title:	Pager/Mobile:
Phone Number:	Notes:

7. Talk to the controls contact (may be the same person you are currently speaking with). Provide an overview of the project. Send the letter if appropriate. Explain that we need to evaluate what data can be obtained from the control system. Confirm the presence of flow and supply/return temperature sensors in the condenser and chilled water loops. Explain that we need sample trend logs, running concurrently for a few hours, for each of these sensors. Work out a plan with this contact for capturing these trend logs (electronic/ printed, tabular/plot) and sending them to us (e-mail, fax, field staff picks them up).

Notes on what field staff need to do to complete this process:

8. We also need a current points list for the control system. Work out a plan for getting a current points list, including any definitions of abbreviations.

Notes on what field staff need to do to complete this process:

9. Schedule the on-site work. If the plans cannot be sent to SBW before the site visit, we need access to the plans at the beginning of the day and will not be ready to meet with these contacts until 10 or later. Meetings at all sites must be scheduled before 1pm so there is time to finish work after the meetings.

	HVAC contact:	Date:	Time:	Place:
	Controls contact:	Date:	Time:	Place:

Notes on scheduling and survey logistics:

Appendix C Example Text from Fax for Site Visit Confirmation

Dear _:

Thank you for agreeing to participate in the HVAC system survey program sponsored by the California Energy Commission. The purpose of this communication is to confirm the arrangements we discussed for the on-site survey and to clarify our data request.

The _ building located at _ is scheduled for our on-site survey on _. Our engineers will go to the security counter at 8:00 am and ask for you. Our engineers will need to meet for approximately 1 hour with a person who is knowledgeable about the HVAC equipment and operation and will also need to meet with your control system operator/programmer for approximately 1 hour. Please arrange for these 2 meetings to occur before noon. At some time during the day our engineers will need access to the chilled water plant and other major equipment rooms.

Our data request is outlined below. I have contacted the Kinko's facility located at _ and am making arrangements for them to 1) pick-up the items you prepare for copying; 2) copy those items and send them to us; 3) return the originals to you and 4) invoice SBW. If you prefer to copy any of the items below and send them to us rather than have Kinko's copy and send, that works fine for us. Please contact the Kinko's at _ (Ph. _) when you are ready to have the materials picked-up for copying. Identify that the copy project is for SBW Consulting, Inc. Indicate the documents are ready for pick-up. Describe where the documents should be picked-up and returned. The Kinko's shop should know to send the copies to SBW and how to handle the invoice. Please call Kinko's by _ to pick-up the documents in order that SBW engineers can receive and review the copies prior to departing for California.

Data Request:

1. Electric and gas billing data for all meters at the above site, for the as many of the last 12 months as are available (I understand you have not been in operation for 12 months).
2. Current points list for the control system, including definitions of abbreviations.
3. Diagrams, schedules and schematics:
    - Control diagram showing typical VAV box controls
    - Mechanical equipment schedule
    - Piping schematic for the chilled water plant
    - Electrical riser diagram
    - System communications riser diagram
    - Intended sequence of operations for air handlers and chillers
    - Manufacturer's test report for each chiller
4. Trend log information: 15-minute (or less) averages of concurrent data for the following parameters taken over a period of at least 3 hours:
    - Outside air temperature
    - Chiller electrical use (amps or power)
    - Chilled water flowrate
    - Chilled water supply temperature
    - Chilled water return temperature
    - Condenser water flowrate
    - Condenser water supply temperature

- Condenser water return temperature

With the exception of outside air temperature, we would like to get this information for each chiller (or each chilled water system if individual chillers are not metered) and condenser system.

The preferred format is an Excel spreadsheet file or other format that is Excel-compatible (e.g. an ASCII file). Printed data are also acceptable, in which the data may be either plotted or tabular. Data may be transmitted via e-mail (ccrawford@sbwconsulting.com), fax (425-822-8119), or sent with the Kinko's materials.

We greatly appreciate your efforts and look forward to working with your staff on this project.

Please contact me if you have any questions or concerns regarding the above items.

Signature

Appendix D Example Site Survey Form

Integrated Design of Large Commercial HVAC Systems Site Survey

Lead Engineer Initials: MN
Date: 3 / 15 / 01
Site ID: 9 D

Facility Information
Repeat this form for each facility at a site. A facility is 1 or more buildings served by a chilled water plant.

Facility's primary use	Office/ Lab/ Data Center				
Climate Zone (Hot/Mild)	Mild	City or closest major city	San Jose		
Gross conditioned floor space	105,000	Percent of conditioned space currently occupied	100 %		
Date of first occupancy	Oct, 1999	Date (or expected date) of full occupancy	Oct, 1999		
Describe any major changes to the facility likely to start during the next 3 years.	None. The company is actively seeking energy conservation ideas	If the facility has recording demand meters, describe the best way to obtain these data.	Yes. The information is available through the EMS.		
Describe the current status of the facility's HVAC systems. Is operation stable? Is the contractor still doing tuning and adjustment? Are there significant problems and how are they being addressed?	No problems				

Take photos of each building in this facility showing basic geometry, typical fenestration and site conditions. *Paste into space below and give each picture an appropriate label.*

Label: East Face (Southeast Corner)

Label: West Face (Southwest Corner)

Label: South Face

Label: North & West "L"

Additional photos:			
Label:		Label:	
Label:		Label:	
Label:		Label:	
Fenestration (approx. +/- 10%)	30 %	Describe significant site issues affecting cooling load.	None

System/Occupancy Areas [Replace checked boxes with ■ when completing electronic copy]					
Divide the conditioned space into areas that are served by the same type of HVAC system (CV or VAV) and that have similar system configuration, occupancy and energy use intensity. Lump minor uses (< 10% of total floor area) with larger areas unless they contain very intense energy uses, e.g., a computer center.					
	Area #1	Primary Use: Data Center		Special Ventilation Requirements: None	
	% of conditioned area (+/- 10%): 15			Approximate watts/sf (all lights and equipment): 6	
	Typical operating schedule: 24/7				
■VAV ☐CV	Major Electrical Process Equipment: Computers and Monitors			Major Gas Process Equipment: none	
	■ Single Duct ☐ Dual Duct		Served by: ■ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ■ Not Powered		Reheat Coil: ☐ Yes➔ ☐ steam ☐ hot water ☐ electric ■ No		
	Type of separate heating system: None				
	Typical Heating Setpoints	Day °F: NA	Night °F: NA	Range of User Control (+/- °F): 0	
	Typical Cooling Setpoints	Day °F: 70	Night °F: 70	Range of User Control (+/- °F): 0	
	Area #2	Primary Use: Office Core		Special Ventilation Requirements: None	
	% of conditioned area (+/- 10%): 33			Approximate watts/sf (all lights and equipment): 2	
	Typical operating schedule: 4 AM to 10 PM				
■VAV ☐CV	Major Electrical Process Equipment: None			Major Gas Process Equipment: None	
	■ Single Duct ☐ Dual Duct		Served by: ■ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ■ Not Powered		Reheat Coil: ☐ Yes➔ ☐ steam ☐ hot water ☐ electric ■ No		
	Type of separate heating system: None				
	Typical Heating Setpoints	Day °F: 70	Night °F: Off	Range of User Control (+/- °F): 0	
	Typical Cooling Setpoints	Day °F: 74	Night °F: Off	Range of User Control (+/- °F): 0	
	Area #3	Primary Use: Office Perimeter		Special Ventilation Requirements: None	
	% of conditioned area (+/- 10%): 49			Approximate watts/sf (all lights and equipment): 2	
	Typical operating schedule: 4 AM to 10 PM				
■VAV ☐CV	Major Electrical Process Equipment: None			Major Gas Process Equipment: None	
	■ Single Duct ☐ Dual Duct		Served by: ■ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ■ Not Powered		Reheat Coil: ■ Yes➔ ☐ steam ■ hot water ☐ electric ☐ No		
	Type of separate heating system: None				
	Typical Heating Setpoints	Day °F: 70	Night °F: Off	Range of User Control (+/- °F): 0	
	Typical Cooling Setpoints	Day °F: 74	Night °F: Off	Range of User Control (+/- °F): 0	

■VAV ☐CV	Area #4	Primary Use: Computer Lab (heat pumps in cooling mode)	Special Ventilation Requirements	
	% of conditioned area (+/- 10%) 3		Approximate watts/sf (all lights and equipment) 6	
	Typical operating schedule: 24/7			
	Major Electrical Process Equipment: Computers and Monitors		Major Gas Process Equipment: None	
	■ Single Duct ☐ Dual Duct	Served by: ■ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ■ Not Powered		Reheat Coil: ☐ Yes➔ ☐ steam ☐ hot water ☐ electric ■ No	
	Type of separate heating system: None			
	Typical Heating Setpoints	Day °F NA	Night °F NA	Range of User Control (+/- °F) 0
	Typical Cooling Setpoints	Day °F 70	Night °F 70	Range of User Control (+/- °F) 0
☐VAV ☐CV	Area #5	Primary Use	Special Ventilation Requirements	
	% of conditioned area (+/- 10%)		Approximate watts/sf (all lights and equipment)	
	Typical operating schedule:			
	Major Electrical Process Equipment		Major Gas Process Equipment	
	☐ Single Duct ☐ Dual Duct	Served by: ☐ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ☐ Not Powered		Reheat Coil: ☐ Yes➔ ☐ steam ☐ hot water ☐ electric ☐ No	
	Type of separate heating system:			
	Typical Heating Setpoints	Day °F	Night °F	Range of User Control (+/- °F)
	Typical Cooling Setpoints	Day °F	Night °F	Range of User Control (+/- °F)
☐VAV ☐CV	Area #6	Primary Use	Special Ventilation Requirements	
	% of conditioned area (+/- 10%)		Approximate watts/sf (all lights and equipment)	
	Typical operating schedule:			
	Major Electrical Process Equipment		Major Gas Process Equipment	
	☐ Single Duct ☐ Dual Duct	Served by: ☐ Water-cooled chilled water plant ☐ Other source		
	Fan Powered VAV Boxes: ☐ Series ☐ Parallel ☐ Not Powered		Reheat Coil: ☐ Yes➔ ☐ steam ☐ hot water ☐ electric ☐ No	
	Type of separate heating system:			
	Typical Heating Setpoints	Day °F	Night °F	Range of User Control (+/- °F)
	Typical Cooling Setpoints	Day °F	Night °F	Range of User Control (+/- °F)

Air Handling [Replace checked boxes with ■ when completing electronic copy]			
Are cooling coil bypass dampers for reduced pressure drop when no cooling required present?	☐ Yes ■ No		
AHU Group #1	# of Units 1	Type ☐ Package ■ Built-up	Serves VAV system ■ Yes ☐ No
Volume control method	■ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):		
Economizer controller type ☐ Local ■ Central ☐ None		Volume controller type ☐ Local ■ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ■ Mechanical room		Heat recovery ☐ Yes ■ No	
Supply fans	# of Fans 2	Total HP 150	Fan Type ■ Centrifugal ☐ Vane-axial
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Exhaust fans	# of Fans 6	Total HP 30	Fan Type ☐ Centrifugal ■ Vane-axial
AHU Group #2	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):		
Economizer controller type ☐ Local ☐ Central ☐ None		Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room		Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
AHU Group #3	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):		
Economizer controller type ☐ Local ☐ Central ☐ None		Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room		Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
AHU Group #4	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):		
Economizer controller type ☐ Local ☐ Central ☐ None		Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room		Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
AHU Group #5	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):		
Economizer controller type ☐ Local ☐ Central ☐ None		Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room		Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial

AHU Group #6	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No	
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):			
Economizer controller type ☐ Local ☐ Central ☐ None			Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room			Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
AHU Group #7	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No	
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):			
Economizer controller type ☐ Local ☐ Central ☐ None			Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room			Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
AHU Group #8	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No	
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):			
Economizer controller type ☐ Local ☐ Central ☐ None			Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room			Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
AHU Group #9	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No	
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):			
Economizer controller type ☐ Local ☐ Central ☐ None			Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room			Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
AHU Group #10	# of Units	Type ☐ Package ☐ Built-up	Serves VAV system ☐ Yes ☐ No	
Volume control method	☐ VSD ☐ Inlet vanes ☐ Variable pitch blades ☐ Outlet damper ☐ Varicone ☐ Other (describe):			
Economizer controller type ☐ Local ☐ Central ☐ None			Volume controller type ☐ Local ☐ Central ☐ None	
Location ☐ Roof top ☐ Floor by floor ☐ Mechanical room			Heat recovery ☐ Yes ☐ No	
Supply fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Return fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	
Exhaust fans	# of Fans	Total HP	Fan Type ☐ Centrifugal ☐ Vane-axial	

Chilled Water Plant [Replace checked boxes with ■ when completing electronic copy]					
Chiller #1	Make York		Model YTH3A2C1- CJH		
Rated Tons 250	Rated Efficiency (kw/Ton)		Fuel Type ■ Electric ☐ Gas		
Condenser	Type ☐ Air- ■ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ■ Constant Flow		
Compressor	Type ■ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	■ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ■ Central DDC ☐ Unitary Controller	Notes on this chiller: Lead/Lag			
Chiller #2	Make York		Model YTH3A2C1- CJH		
Rated Tons 250	Rated Efficiency (kw/Ton)		Fuel Type ■ Electric ☐ Gas		
Condenser	Type ☐ Air- ■ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ■ Constant Flow		
Compressor	Type ■ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	■ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ■ Central DDC ☐ Unitary Controller	Notes on this chiller: Lead/Lag			
Chiller #3	Make		Model		
Rated Tons	Rated Efficiency (kw/Ton)		Fuel Type ☐ Electric ☐ Gas		
Condenser	Type ☐ Air- ☐ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ☐ Constant Flow		
Compressor	Type ☐ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	☐ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ☐ Central DDC ☐ Unitary Controller	Notes on this chiller:			
Chiller #4	Make		Model		
Rated Tons	Rated Efficiency (kw/Ton)		Fuel Type ☐ Electric ☐ Gas		
Condenser	Type ☐ Air- ☐ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ☐ Constant Flow		
Compressor	Type ☐ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	☐ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ☐ Central DDC ☐ Unitary Controller	Notes on this chiller:			
Chiller #5	Make		Model		
Rated Tons	Rated Efficiency (kw/Ton)		Fuel Type ☐ Electric ☐ Gas		
Condenser	Type ☐ Air- ☐ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ☐ Constant Flow		
Compressor	Type ☐ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	☐ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ☐ Central DDC ☐ Unitary Controller	Notes on this chiller:			
Chiller #6	Make		Model		
Rated Tons	Rated Efficiency (kw/Ton)		Fuel Type ☐ Electric ☐ Gas		
Condenser	Type ☐ Air- ☐ Water-cooled ➔➔➔		Flow control ☐ VSD ☐ Valve ☐ Constant Flow		
Compressor	Type ☐ Centrifugal ☐ Screw ☐ Reciprocating ➔➔➔		Capacity control	☐ VSD ☐ Unloading ☐ Inlet vane ☐ None	
Start/Stop Control	☐ Manual ☐ Central DDC ☐ Unitary Controller	Notes on this chiller:			

Notes on chiller configuration or features:

Chiller Sequencing	☐ local ■ central DDC ☐ None				
Chilled water distribution	Loop layout ☐ Primary ■ Primary/Secondary ☐ Other				
Primary Loop			Secondary Loop		
HP 15	# of Pumps 2	VSD ☐Yes ■No	HP 15	# of Pumps 2	VSD ■Yes ☐ No
HP	# of Pumps	VSD ☐Yes ☐No	HP	# of Pumps	VSD ☐Yes ☐ No
HP	# of Pumps	VSD ☐Yes ☐No	HP	# of Pumps	VSD ☐Yes ☐ No
			HP	# of Pumps	VSD ☐Yes ☐ No
			HP	# of Pumps	VSD ☐Yes ☐ No
			HP	# of Pumps	VSD ☐Yes ☐ No

Cooling Tower	Type ■ Open ☐ Closed/fluid cooler	Max Fan HP 50	Heat rejection tons 264
Fan Type ■ Axial ☐ Centrifugal	Fan Speed Control ☐ Multi-speed ■ VSD ☐ Constant Speed		
# of Fans 2	# of Cooling tower cells 2		

Notes on configuration or operation of chilled water plant:
2 building loop pipes supply water for the water source heat pumps. 10 hp total, VSD controlled.
2 Cooling Tower pump loops for the flat plate heat exchanger. 10 hp total, constant volume flow.

Central Controls [Replace checked boxes with ■ when completing electronic copy]

HVAC Controls	Make Automated Logic	Model ALDC		Pneumatic components	☐ Yes ■ No
Special Control Algorithms					
Supply air temperature reset control	☐ Available, but not used ■ in use ☐ not available				
Supply air pressure reset control	■ Available, but not used ☐ in use ☐ not available				
Lighting Controls	■ Yes ☐ No	If separate Lighting control system			
		Make Watt - Stopper	Model		

Sensors and Trend Logs		Annually calibrated sensors Not available on site	Trend Log Attached	Calibration Doc Attached	Signal to DDC (4-20, 0-5, etc)
Chiller #1	Energy	■ Amp ☐ kW ☐ None	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	
	Chilled Water	■ Supply temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		■ Return Temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
	Condenser Water	■ Supply temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		■ Return Temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
Chiller #2	Energy	■ Amp ☐ kW ☐ None	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	
	Chilled Water	■ Supply temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		■ Return Temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
	Condenser Water	■ Supply temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		■ Return Temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
Chiller #3	Energy	☐ Amp ☐ kW ☐ None	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Chilled Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Condenser Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
Chiller #4	Energy	☐ Amp ☐ kW ☐ None	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Chilled Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Condenser Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
Chiller #5	Energy	☐ Amp ☐ kW ☐ None	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Chilled Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Condenser Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
Chiller #6	Energy	☐ Amp ☐ kW ☐ None	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Chilled Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Condenser Water	☐ Supply temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Flow	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
		☐ Return Temp	☐ Yes ☐ No ☐ NA	☐ Yes ☐ No ☐ NA	
	Chilled Water Distribution (Primary Loop)	■ Supply temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		■ Flow	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
		■ Return Temp	■ Yes ☐ No ☐ NA	☐ Yes ☐ No ■ NA	4-20 mA
	Outside Air	■ temp	☐ Yes ■ No ☐ NA	☐ Yes ☐ No ■ NA	

Central Controls [Replace checked boxes with ■ when completing electronic copy]	
Trend log capability and issues	
Can trend logs be exported to a file?	■ yes ☐ no
What is the capacity of each trend log? Number of readings	4 ~ 6
What is the smallest recording interval, e.g., 1-minute, 15-minute, etc.?	5 seconds
How many points can the system simultaneously log?	Unknown
Can these trend logs be accessed via an Internet or dial-up connection to the system?	■ yes ☐ no
Could the operator e-mail trend logs to the study team on a regular basis?	■ yes ☐ no
Other relevant information about the control system or its ability to do trend logging.	

Documentation Checklist [Replace checked boxes with ■ when completing electronic copy]		
■ Attached ☐ Available on site ☐ Not Available	Energy billing records	Notes:
■ Attached ☐ Available on site ☐ Not Available	Mechanical equipment schedule	Notes:
■ Attached ☐ Available on site ☐ Not Available	Piping schematic for chilled water plant	Notes:
■ Attached ☐ Available on site ☐ Not Available	Manufacturer's test report for each chiller (listing capacity, kW, evaporator and condenser flow and temperature, and part load efficiency)	Notes:
■ Attached ☐ Available on site ☐ Not Available	Intended sequence of operation	Notes:
■ Attached ☐ Available on site ☐ Not Available	Control system communications riser	Notes:
■ Attached ☐ Available on site ☐ Not Available	Control system points list (current system configuration) , central plant and typical AHU's and occupied areas.	Notes:
■ Attached ☐ Available on site ☐ Not Available	Electrical rise diagram	Notes:

Interest in Monitoring [Replace checked boxes with ■ when completing electronic copy]		
If selected, can monitoring proceed at this facility? ■ Yes ☐ No	Reason(s) for "No"	
Describe conditions or restrictions associated with "Yes"	None	
Describe any barriers to making cost-effective efficiency improvements to HVAC system during the spring of next year e.g. system operation cannot be interrupted? Security issues? Other?	If payback < 1 year: No hindrance If 1 year > payback < 2 years: Significant discussion If payback > 2 years: Not likely	